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(54) **Method for encapsulating an integrated circuit.**

(57) Method for encapsulating an integrated semiconductor circuit (die) comprising the following steps:

a) mounting the semiconductor circuit onto the supporting surface of a so-called lead frame,

b) attaching connecting wires between the contact pads of the semiconductor circuit and selected parts of the lead frame (bonding),

c) producing a plastic package by means of a mould, which package surrounds at least the semiconductor circuit, the supporting surface, the connecting wires and part of the lead frame.

According to the invention between the steps b) and c) the additional step is carried out:

d) supplying a predetermined volume of radiation transparent plastic at that side of the semiconductor circuit opposite the side which is attached to the supporting surface, which plastic has a glass temperature lower than the temperature which is used for carrying out step c).

fig - 1a

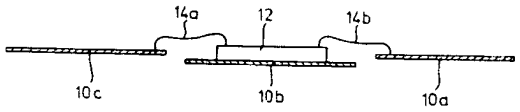


fig - 1b

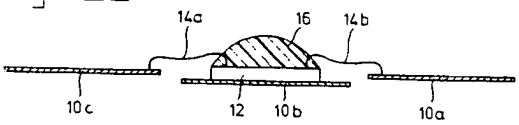


fig - 1c

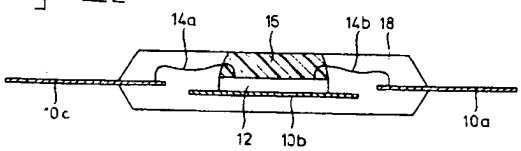
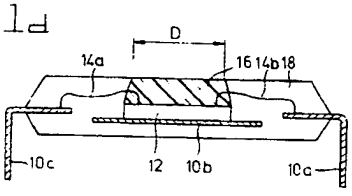


fig - 1d



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The invention relates to a method for encapsulating an integrated semiconductor circuit (die) comprising the following steps:

a) mounting the semiconductor circuit onto the supporting surface of a so-called lead frame,

b) attaching connecting wires between the contact pads of the semiconductor circuit and selected parts of the lead frame (bending),

c) producing a plastic package by means of a mould, which package surrounds at least the semiconductor circuit, the supporting surface, the connecting wires and part of the lead frame.

The invention is specifically direction to a method for obtaining an encapsulation around an integrated circuit comprising opto-electronic components whereby the encapsulation has to contain a radiation transparent window. The term radiation covers in a broad sense both radiation in the visible part of the spectrum and also radiation in the infrared or ultraviolet part of the spectrum.

In the US Patent US-5,200,367 on the one hand a description is provided of so-called ceramic enclosures and on the other hand a description is provided of a plastic encapsulation which can be used as a replacement for a ceramic enclosure. In both cases the enclosure is embodied such that the integrated circuit at the side, where the radiation should impinge on the circuit, is open. This open side can be covered thereafter by a separate glass platelet, or, in case the integrated circuit does not comprise any light sensitive components, can be covered by a platelet of another material, such as a metal platelet.

It is considered well known that the use of ceramic enclosures will result into an increase of costs of the ultimate electronic component. Ceramic enclosures are therefore almost exclusively used for components which have to fulfil high requirements. Furthermore the use of a separate glass covering platelet has a number of disadvantages. A special glue or adhesive is necessary to attach the platelet to the respective section of the enclosure. Furthermore it is not possible, without taking further measures, to restrict the incidence of light to a window which is located at a predetermined positioned above the integrated circuit. A further disadvantage remains in the fact that changing temperatures may lead to stress which may cause loosening or burst of the glass platelet or may cause bursting or other damage to the enclosure.

A method whereby instead of a glass cover platelet use is made of a transparent plastic which is moulded into the open space and which fills this space completely, is for instance described in the European patent application EP-0,400,176. The disadvantage of said method is that no use is made of standard (open tooling) basic elements, so that the costs of this method are relatively high.

Furthermore methods are known, for instance from the Japanese patent application JP60193345, whereby first of all a layer of transparent plastic is deposited onto the semiconductor circuit using a separate mould, which layer after hardening forms the future light window. Thereafter the upper side of this light window is provided with a protection layer and the so obtained half finished product is encapsulated using another mould such that the complete enclosure is obtained. Finally the protecting layer is removed from the window. This method has the disadvantage that the method as such has a large number of steps, whereby furthermore two different moulds are necessary to obtain the final result.

The object of the invention is now to indicate in which way, using a standard mould and using usual, so-called "open tooling" lead frame, an integrated circuit can be provided within an encapsulation containing a window.

According to the invention said object is fulfilled with a method as described in the first paragraph, in that between the steps b) and c) the additional step is carried out:

d) supplying a predetermined volume of radiation transparent plastic at that side of the semiconductor circuit opposite the side which is attached to the supporting surface, which plastic has a glass temperature lower than the temperature which is used for carrying out step c).

The invention will be explained in more detail with reference to the attached drawings.

Figure 1 illustrates in a number of views 1A...1D a number of stages during the application of the method according to the invention.

Figure 2 illustrates in a number of views 2A...2D a number of stages during the application of the procedure according to the invention in case an additional distance element is applied.

Figure 3 illustrates in a number of views a similar method as illustrated in figure 2, however, in this case applying a differently shaped distance element.

Figure 4 illustrates a cross section through a mould preferably used within the scope of the invention.

Figure 5 illustrates a cross section through an enclosure, made with the mould illustrated in figure 4.

Figure 6 illustrates a cross section through a differently embodied enclosure.

In the figures 1A ... 1D various successive stages during the application of the method according to the invention are indicated.

During the fabrication of integrated semiconductor circuits in general a large number of these circuits are manufactured simultaneously onto one

single large flat silicon plate, a so-called wafer. After completing the integration process the wafer is subdivided into the separate semiconductor circuits or chips using known techniques, such as cutting or etching. (In English literature the terms "die" or "pellet are also used instead of chip.) Each chip is thereafter positioned onto a metal framework comprising a number of contact pins which are mutually connected by means of interconnecting sections such that as a whole a so-called lead frame is formed. The central section (paddle or stem) of such a lead frame comprises a supporting surface onto which the chip can be located and fixed by means of soldering or in another manner, known as such. After fastening the chip in this manner to the central section of the lead frame the bonding wires are attached between the various contact pins and the connecting surfaces or "pads" on the chip. The result after completing this step is schematically illustrated in cross section in figure 1A.

In figure 1A the parts of the lead frame are indicated with 10a, 10b and 10c. The contact pins are formed by the parts 10a and 10c, whereas the central mounting surface of the lead frame is indicated by 10b. Onto this mounting surface 10b (in English called "die pad") the chip 12 is fastened in a known manner, which does not play a role within the scope of the invention. Furthermore, inbetween the connecting pins 10a and 10c on the one hand and the chip 12 on the other hand, bonding wires 14a and 14b are installed. All these techniques are known as such and do not require any further explanation.

The next step in the method is illustrated in figure 1B. In this step dosing means, known per se, are used to deposit a small amount of a suitable transparent resin 16 onto the upper surface of the chip 12. The consistency of the resin 16 is such that a somewhat spherical layer remains on the chip 12. After depositing the layer 16, this layer is at least partly hardened before the next step of the method is carried out.

For carrying out the next method step the now obtained half finished product is positioned in a mould, which is known per se, for making an enclosure around the half finished product. The resin for manufacturing the enclosure is processed at a temperature which is higher than the glass temperature Tg of the transparent resin 16, so that at least during the moulding process said resin 16 will be softened to some degree. The result thereof is that the upper side of the layer 16 is pressed flat against the wall of the mould, whereas simultaneously the remaining free space in the mould is filled with the encapsulating resin 18. After at least partly hardening of the now encapsulated semiconductor circuit and after removing the circuit from the mould the product is obtained which is in cross section illustrated in figure 1C. The degree of hardening of the resin 16 and also the volume of the resin both have influence on the diameter D of the ultimately obtained window (see figure 1D).

The next steps to obtain a usable end result are known as such. To start with the still present connecting parts between the separate contact pins 10a, 10c, etc., should be removed so that these pins in an electrical sense do not provide a short circuit and thereafter, or eventually simultaneously, these pins should be banded into the desired shape, for instance perpendicular downwards as illustrated in figure 1D.

For the quality of the ultimately realized window comprising enclosure (formed by the transparent section 16 of the enclosure) the resin, of which the section 16 is formed, has to fulfil a number of requirements:

1) The resin should be highly transparent for the radiation, which has to pass the window 16, which radiation may be in the visible part of the spectrum but also in the ultraviolet or infrared part of the spectrum.

2) The resin should have a glass temperature Tg underneath the temperature at which the resin 18 is processed in the mould, so that because of the weakening of the transparent resin as result thereof, this resin can adapt the ultimately desired shape during the moulding process.

To obtain a window with the same optical path length over the whole surface of the chip the upper surface of the chip 12 and the upper surface of the window 16 should be essentially parallel. Therefore, the quality of the final product is also determined by the extent with which the upper surface of the chip 12 runs parallel to the upper surface of the window 16. In other words, the manner in which the height of the window 16 above the chip 12 is constant. In this relation it is in agreement with the invention proposed to obtain a fixation of the chip 12 especially during the application of the encapsulating resin 18, by attaching a distance element 12 underneath the mounting surface 10b before carrying out this step. The use of this distance element is illustrated in detail in figure 2.

In the figures 2A ... 2D is, in the same manner as in figure 1, a series of situations illustrated which arise during the method according to the invention, whereby use is made of a separate distance element 20. The situation in figure 2A is in fact comparable with the situation in figure 1a with the difference that now a distance element 20 is attached to the underside of the mounting plate 10b using techniques which are known as such, such as soldering, gluing, etc.

Thereafter a predetermined amount of transparent resin 16 is applied to the upper surface of the chip 12 and this transparent resin is partly hardened resulting into the semi-manufactured product, the cross section of which is illustrated in figure 2B. The amount of transparent resin 16, applied in figure 2B, is larger than the amount used in figure 1B with the result that not only the chip 12 but also at least a part of the mounting surface 10b is covered by the resin.

Thereafter this half finished product is inserted into a mould and the encapsulating resin 18 is transferred into the mould at a predetermined relatively high temperature. During this procedure pressure will be applied to the upper side of the mould (as seen in the situation according to figure 2C) in downwards direction onto the initial surplus of the transparent resin 16. As a result of the presence of the distance element 20, supported by the lower side of the mould, the chip will not undergo any displacement because of this pressure, on the contrary, the chip will be definitely secured in place. If it is assumed that the inner walls of the mould 20 are extending parallel and that the distance element 20 has a uniform thickness, then the final result is an encapsulated chip whereby the upper surface of the chip 12 extends parallel to the upper surface of the encapsulation so that the window 16 has a uniform thickness. Because a larger amount of resin was applied, also the diameter D of the obtained window is larger than in figure 1D.

It will be clear that by selecting the suitable dimensions of the distance element 20, the thickness of the transparent resin 16 can be predetermined accurately. Because furthermore the conditions during the moulding process are well reproducible, it is possible to predetermine empirically the volume of transparent resin which should be applied onto the upper surface of the chip 12 to obtain the situation of figure 2B, and to obtain finally, after the reshaping process in the mould, a window with accurately determined dimensions.

In the figures 3A ... 3D again, in the same manner as in figures 1 and 2, a series of situations are illustrated which will arise in the course of a method according to the invention, whereby now the used distance element 20' is shaped somewhat differently. As appears from the various figures the distance element 20' is embodied as a relatively thin flat plate with a number of legs or ribs which form the actual distance determining parts. The result of using such a distance element 20' is that almost the whole distance element is embedded in the encapsulating resin. Therewith a tight connection between the resin and the distance element 20' is obtained.

To illustrate the flexibility of the method even further in figures 3B a relatively small amount of resin is applied, so that only part of the surface of the chip 20 is covered. It will be clear that in the end result, illustrated in figure 3D, the diameter of the window D will be smaller than that of the windows illustrated in figures 1D and 2D.

According to the invention it is preferred to manufacture the distance element 20 out of a heat conducting material, which has preferably the same expansion coefficient as the encapsulating resin 18.

A distance element made of metal such as brass, has the additional advantage that therewith a screening function can be obtained.

The upper surface of the window 16 at the outside of the encapsulation should preferably be as smooth as possible to obtain less or no dispersion of the impinging light. A high degree of smoothness can be obtained by locally finishing the inner wall of the mould 30.

Figure 4 illustrates a cross section through a mould 30, comprising the lower half 30b and the upper half 30a. Part of the inner wall of the upper section 30a, roughly indicated by the distance indication 34a, will during the manufacturing process come into contact with the transparent resin 16. If this respective section 34a is given a smooth finish, for instance by polishing or in another suitable manner, then also the products, made with such a mould, will obtain a smooth surface at the upper side of the window 16. Preferably the mould is finished such, that the upper side of the window 16 has a surface roughness Ra better than 0.2.

To protect the smooth surface of the window 16 as good as possible against external influences it is preferred to manufacture a number of extending parts to the upper side of the enclosure so that the chance on scratches or other damages of the surface of the window 16 is reduced. For that purpose the mould, as is illustrated in figure 4, comprises a number of excavations 32a, 32b, ..., taking care that the finished product, which is schematically illustrated in figure 5, comprises a number of outwardly extending parts 36a, 36b ... . It is pointed out in figure 5 that the schematically indicated surface 34b, at least including the upper side of the window 16, has a very low roughness within the above indicated margins as result of the finishing of the section 34a of the inner wall of the mould 30.

Figure 6 illustrates a further embodiment of an enclosure which can be manufactured using the method according to the invention. The difference between figure 1D and figure 6 is recognized in the fact that the upper surface of the window 17 has a concave shape, providing a functional lens and resulting into more or less focusing the impinging radiation onto a predetermined section of the chip

12. It will be clear, also without further illustration, that the inner wall of the upper section 30a of the mould 30 should comprise a convex excavation shaped in such a manner, that therewith the desired concave bulge of the window 16 can be obtained.

If desired, also the inverted situation is possible, whereby as a result a convex shaped surface of the window 16 can be realizes.

It will be clear that the mould can be shaped such that only a part of the window has a concave or convex surface whereas the remaining section is flat.

Suitable resins for manufacturing the window 16 are commercially available. As an example the attention is drawn to the product Amicon Me 45 W, a crystal-clear two-component resin hardening at room temperature. This resin is amongst others supplied by the firm Grace in Westerlo. Another resin is Hysol EPR 250-1, an optically crystal-clear epoxy resin transmitting radiation even into the ultraviolet part of the spectrum. This resin, which is supplied by The Dexter Corporation, California, U.S.A., is especially suited in case the chip for instance has to be programmed by means of UV-radiation, such as is done with some types of EPROMs.

Although in the various figures the finally obtained component (see figures 1D, 2D, 3D, 5, and 6) is destined for pin hole mounting, it will be clear that with another finishing of the extending lead pins also so-called SMD-components, components which are suited for surface mounting, can be obtained.

Claims

1. Method for encapsulating an integrated semiconductor circuit (die) comprising the following steps:
   a) mounting the semiconductor circuit onto the supporting surface of a so-called lead frame,
   b) attaching connecting wires between the contact pads of the semiconductor circuit and selected parts of the lead frame (bonding),
   c) producing a plastic package by means of a mould, which package surrounds at least the semiconductor circuit, the supporting surface, the connecting wires and part of the lead frame,
   characterized in that between the steps b) and c) the additional step is carried out:
   d) supplying a predetermined volume of radiation transparent plastic at that side of the semiconductor circuit opposite the side which is attached to the supporting surface, which plastic has a glass temperature lower than the temperature which is used for carrying out step c).

2. Method according to claim 1, characterized in that preceding step c) a distancing element is attached to the free side of the supporting surface.

3. Method according to claim 2, characterized in that the distancing element consists of a plate of which the thickness corresponds to the desired distance.

4. Method according to claim 2, characterized in that said distancing element consists in general of a flat element with locally extending parts which determine the desired distance.

5. Method according to one of the claims 2-4, characterized in that the distancing element is manufacturing from heat conducting material.

6. Method according to one of the claims 2-5, characterized in that the distancing element is manufacturing from metal.

7. Mould for use in a method according to one of the preceding claims, comprising two or more releasable parts which together define a space corresponding to the desired external shape of the plastic encapsulation, characterized in that part of the inner wall of the mould, which comes in contact with the transparent plastic applied in step d) has a smooth finish with a surface roughness Ra better than 0.2.

8. Mould according to claim 7, characterized in that the respective part of the inner wall of the mould has furthermore at least partly a concave or convex rounded surface.

9. Mould according to claim 7 or 8, characterized in that the remaining section of the respective inner wall comprises excavations which after terminating the encapsulation process result into outwardly extending parts on the surface of the encapsulation adjacent the transparent plastic.

fig-1a

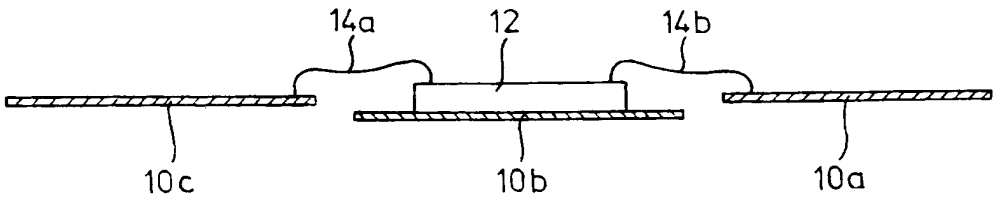


fig-1b

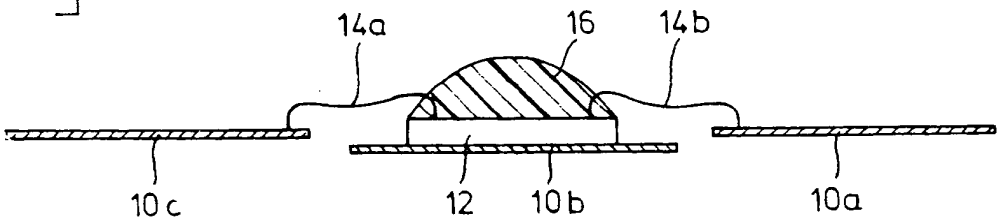


fig-1c

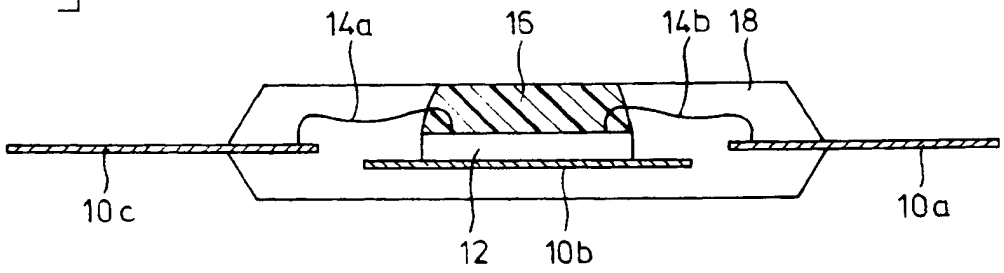


fig-1d

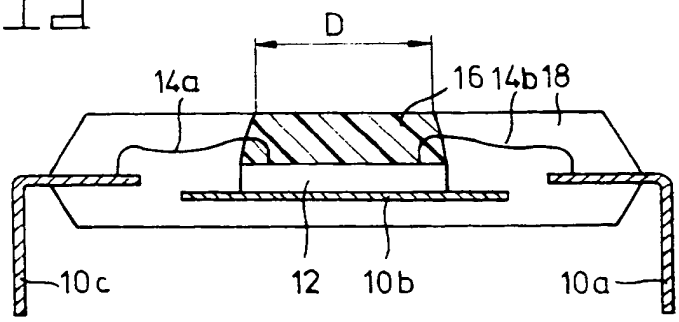


fig-2a

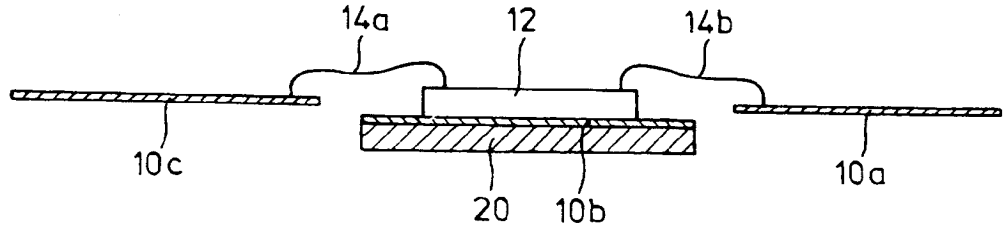


fig-2b

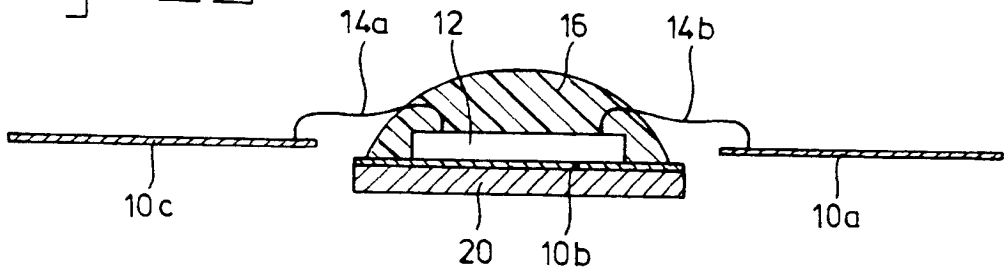


fig-2c

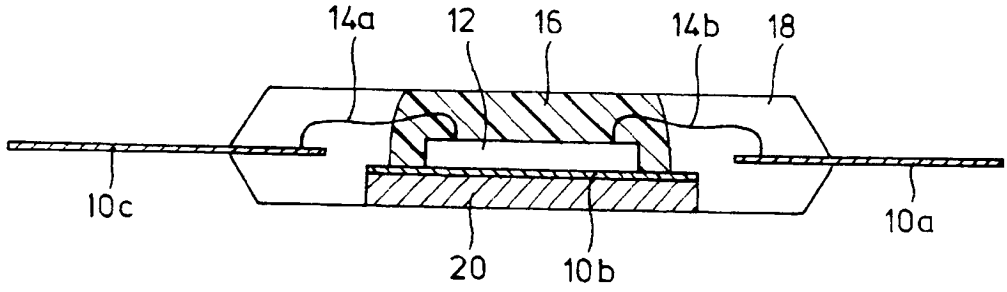


fig-2d

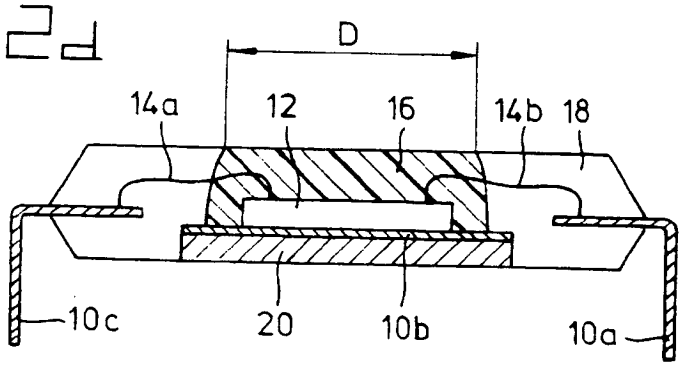


Fig - 3a

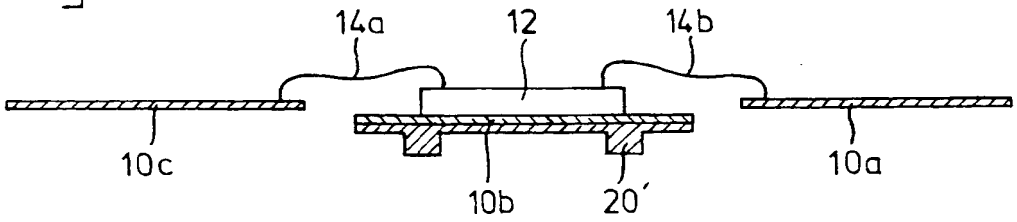


Fig - 3b

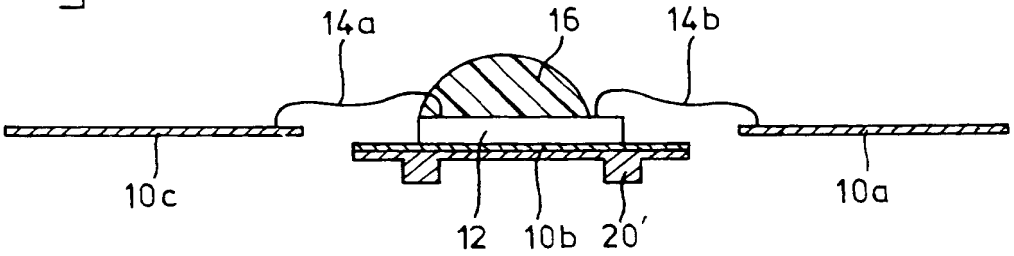


Fig - 3c

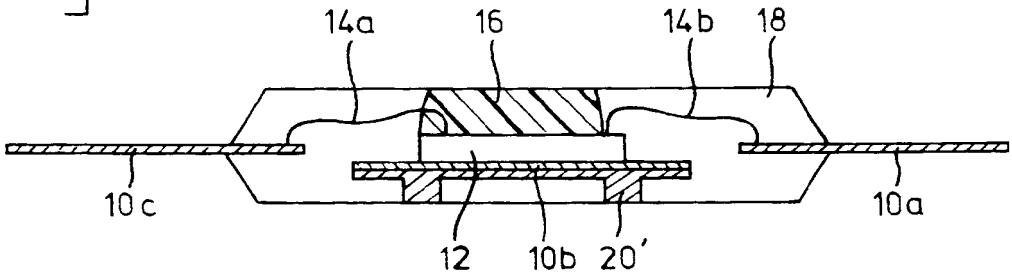


Fig - 3d

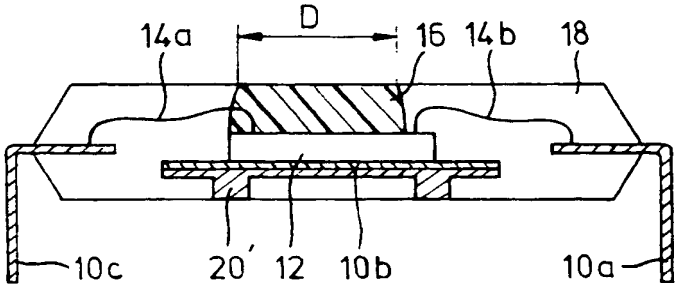


Fig-4

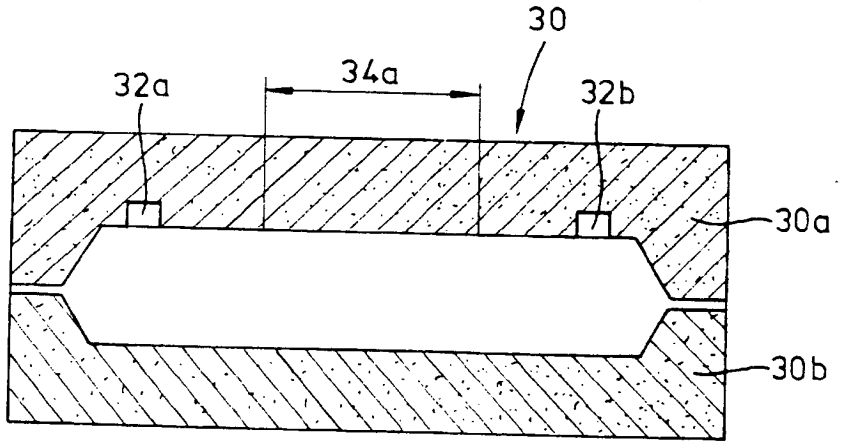


Fig-5

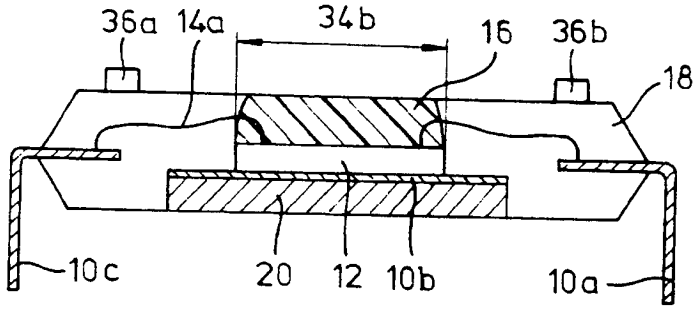
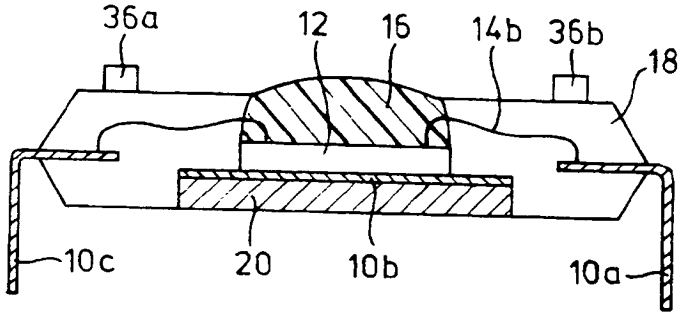


Fig-6



European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 95 20 1126

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	PATENT ABSTRACTS OF JAPAN vol. 10 no. 192 (E-417) ,5 July 1986 & JP-A-61 036957 (NEC CORP) 21 February 1986, * abstract * ---	1,7	H01L31/0203 H01L33/00
A	PATENT ABSTRACTS OF JAPAN vol. 12 no. 314 (E-649) ,25 August 1988 & JP-A-63 078557 (HITACHI LTD) 8 April 1988, * abstract * ---	1,7	
A	PATENT ABSTRACTS OF JAPAN vol. 12 no. 150 (E-606) ,10 May 1988 & JP-A-62 265771 (SEIKO INSTR & ELECTRONICS LTD) 18 November 1987, * abstract * ---	7-9	
A,D	EP,A,0 400 176 (SIEMENS AKTIENGESELLSCHAFT) 5 December 1990 * the whole document * ---	1	TECHNICAL FIELDS SEARCHED (Int.Cl.6)
A,D	US,A,5 200 367 (KO) 6 April 1993 * the whole document * ---	1	H01L
A,D	PATENT ABSTRACTS OF JAPAN vol. 10 no. 35 (E-380) ,12 February 1986 & JP-A-60 193345 (MATSUSHITA DENSHI KOGYO KK) 1 October 1985, * abstract * -----	1	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	20 July 1995	Lina, F

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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E : earlier patent document, but published on, or after the filing date
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L : document cited for other reasons

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